A STUDY OF THE JUDGING OF WOMEN'S
SIDE HORSE VAULTING

by

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CHAPTER I

THE PROBLEM

Introduction

To evaluate and grade performance with consistency and objectivity is a problem which faces all teachers. To solve it, the physical education teacher faces difficulties, many of which are unique with each sport or activity. This is especially so when the usual standards, such as speed, accuracy and distance, are not an apparent or measurable issue. Such is the case in gymnastics.

To rate individual performances in gymnastics, the teacher, coach, or judge may consider the difficulty of the techniques performed in establishing a part of the grade. Beyond that, much of the criteria left for consideration involves personal opinion. In an attempt toward objectivity in reaching the opinion, many guidelines have been established for the observer to consider. Nevertheless, the judgment is largely subjective, with the interpretation of such guidelines left to individual preferences of the observer and his perceptual skill in noting the important established aspects of the performance.

In side horse vaulting the problem becomes more acute, because of the short duration of the vault. Within a fraction of a second the observer must consider many aspects of the performance, and establish a score. If one were to record a basketball player's score in the same fashion during a game, he would not limit his entries to how many baskets were scored by the player. He would judge the manner in which the
player achieved the score. How high did he jump on the jump shot? Did he release it at the height of his jump? Did he flex his wrist and release the ball off of his finger tips? If it was a lay-up shot, did he place the ball high enough on the backboard? According to the answers to these and various other questions the scorer would add or deduct certain point fractions to the score. The teacher or coach may or may not consider these as important aspects when grading or instructing during the training phase, but in competition, the ultimate record is how many times the player got the ball into the basket, with no concern for the form he used. The analogy could continue into other sports, but this one may begin to clarify the problem of the gymnast and the person assigned the task of judging his performance.

In order to score the vaulter accurately and consistently the judge must not only know what to look for, but also be able to see it in less than two seconds' time. This becomes increasingly difficult in gymnastics meets with large numbers of vaulters of similar ability performing the same vault. It is also especially difficult when vaulters perform different vaults of the same point value in difficulty. How does a judge determine that a straight arm handspring with a turning off flight performed by one individual is better than a regular straight arm handspring performed by another? Both are considered ten point vaults, although the former is actually more difficult.

Regardless of the performance level, whether it be in a gymnastics class, a high school meet, or at the national championships, the gymnast has the right to be judged accurately and as objectively as possible. The problem is how accurate can the judging be under the present methods used, and in what way can it become more objective?
Purpose of the Study

The purpose of this study was to examine certain aspects of the judging of women gymnasts in side horse vaulting competition. More specifically, this paper was concerned with: (1) the feasibility of using the time of the vault as a factor in its evaluation, (2) the consistency of judges in scoring vaulters under the present standards, and (3) certain kinesiological aspects of vaulting action and their relationships to scores achieved.

Scope of the Study

The study involved gathering data at a pilot study of high school women's gymnastics meets and two major gymnastics meets of 1967; the National A.A.U. Gymnastics Meet at Natchitoches, Louisiana; and the Pan-American Games at Winnipeg, Canada. At the National Meet, two phases of the layout straddle vault were timed for comparison with the scores of each of five judges and the average of the three middle scores. One hundred thirty-six trials were timed from the point of take-off to the point of landing with an electric timer. Optional vaults were timed also. In addition, forty-eight layout straddle vaults were filmed with a 16mm. camera at 1/64 second shutter speed. Ten angles of body position during three phases of the touch were measured with a protractor to the nearest degree, through the use of a micro-film reader and projector. The projector was also used to measure the duration of time that the vaulters were in contact with the horse.

At the Pan-American Games, forty-eight trials of the layout straddle vault were filmed with a 16mm. camera at 1/64 second shutter speed. The average score of each trial was recorded. The film was
used for deriving time durations of three phases of the vault: (1) pre-flight, (2) duration of touch, and (3) after-flight. A micro-film projector was used to trace certain phases of the most successful straddle vault. In addition, the optional vaults were timed with the electric timer.

The data from each of these gymnastics meets were compiled and computed separately for intercorrelations. Kinesiological analyses were made from tracings of certain vaults.

For interpretation of judging procedures, a three-day judging course, presented by a representative of the International Federation of Gymnastics, was attended at Shreveport, Louisiana. Data received from this clinic is included within the review of literature.

**Limitations of the Study**

It must be stated that this study does not measure or analyze all factors involved in side horse vaulting. The timing was restricted to phases starting with the take-off, and does not consider the length or speed of the running approach, which could be important factors affecting the vault. Times of the running approach to the take-off were recorded but since the starting points varied with each vaulter and were unobtainable, these times were not included for intercorrelations. Also, the distance between take-off board and horse, which varies considerably with each vaulter, is not considered here.

The fact that much of this study included human judgment and reaction must be listed as a limitation also. Although there was clear view of the performers so that the operator could see when the timer should be started and stopped, the consistency with which it was controlled with each take-off and landing must be considered. In addition,
the scores of each judge involved her reaction to a performance. It cannot be determined whether she would react with the exact same score to the same quality vault at another given time. For this reason the greatest number of vaults possible were used to evaluate a certain aspect of the study.
DEFINITIONS AND ABBREVIATIONS

1. Average score - The score determined by deleting the highest and the lowest score, and taking the average of the middle scores.

2. Panning the camera - The term used for moving the camera or rotating it so as to keep an object in the picture.

3. Total vault time - The duration of time elapsing from the moment of take-off to the moment of landing.

4. Take-off - The moment at which the feet first contact the take-off board. (for the purpose of this study)

5. Touch time - The duration of time elapsed from the moment a part of one or both hands first contact the horse, until the push-off.

6. Moment of touch - For measurement purposes, the time at which the heel of one or both hands is clearly in contact with the horse.

7. Landing - The moment at which the feet first contact the mat after completing the vault. This did not include the time consumed in extra steps after the landing. When measuring the time on film, the landing was established as the time when one or both heels were in obvious contact with the mat.

8. Pre-flight - The time elapsed from the moment both feet are clearly apart from the take-off board until the moment of touch. (see 6.)

9. Push-off - The moment both hands are clearly apart from the horse.

10. After-flight - The time elapsed between the push-off and the landing.

11. Nationals - The annual Amateur Athletic Union National Gymnastics Meet, more specifically, the 1967 Meet.


13. F. I. G. - The International Federation for Gymnastics.
CHAPTER II

REVIEW OF LITERATURE

Introduction

In order to judge an event, one must have knowledge about that event; thus, before one can study the judging of side horse vaulting, it is necessary to understand the techniques of vaulting action and the rules which govern it. For this reason, within the review of present judging standards and philosophies interpreting them, current coaching trends implemented toward achieving performance standards will be included. Although there is no evidence of studies which correlate vault times with vault scores, there has been considerable research pertaining to the objectivity of judging. Some, along with other research which relates to this study, will be discussed accordingly.

The Status of Vaulting in the United States

Although women gymnasts from the United States have competed internationally since the 1936 Olympics (32), the nationwide emphasis toward upgrading performance opportunities to the competitive standards within school programs was not initiated until 1963, with the First National Institute on Girls and Women's Sports. Within the framework of this five-day institute, two primary aims were obvious. First, the expressed goal of the Institute: to increase the depth of experiences and expand the opportunities for girls and women in sports; (17) secondly, the underlying message: to let the public know that the Division for Girls and Women's Sports was not against competition for women. (25)
There were other significant aspects of this institute and the Second National Institute held in 1965. First, the Institutes were co-sponsored by the U.S. Olympic committee, which helped provide experts for instruction, including former Olympic performers and coaches. Secondly, it has been estimated that nearly 1.4 million students and teachers benefited indirectly from the first Institute alone through State clinics which relayed the information. (17) Thirdly, most of the books published in the United States on the coaching and judging of gymnastics have been published since 1963, the year of the first Institute.

In addition to these factors, the United States Gymnastics Federation was organized. Its rapid development has resulted in the establishment of compulsory exercises at graded levels, bringing uniformity to all levels of performance. (12, 36) It would appear that this evidence indicates a current and impressive campaign to upgrade the instruction, performance, and competition in women's gymnastics.

**Preliminary Phases in Vaulting**

There are three techniques involved in vaulting action which are not considered by the judge in competition, but which are viewed as essential to master for success in the vault. These are: the running approach, the hurdle to the take-off board, and the landing on the take-off board. Each will be discussed as it contributes to the vault.

**The Run**

Much emphasis is put on the importance of the running approach. (2, 14, 29, 31, 34, 35) Norman (29) incorporates running instruction and practice in group floor exercises with the philosophy that it is the basis for all gymnastics. Frederick (15, 16) suggests that coaches should
refer to books on track and field, stressing that, "Running must be mechanically correct"; he infers that women especially need coaching in this skill, because poor running form is characteristic to their sex. Both Frederick and Norman stressed continued practice in running before actual vaulting practice begins. Further, as the gymnasts attempt more difficult vaults, the running speed and distance increases, requiring more concentrated practice. (9, 31, 34) Frederick (16) suggests the following as essential for a vaulter to know:

1. On which foot she starts her run.
2. The actual number of her running steps from start to hurdle.
3. On which foot she initiates the hurdle step.
4. How many inches she places the take-off board from the horse for each of her vaults.

The Hurdle

The hurdle step is described alternately as a leap, a jump, or a skip, depending on the author. Regardless of the title, the description is basically the same, and all agree that it should occur without a break in the run. (9, 15, 31, 35) Tenterova (33) stated that the running speed should be increased just prior to the hurdle. Drury and Schmid (9) describe the hurdle as an extension of the run: "The last running step before the jump on the beat board is the longest and is almost a leap so as to land on both feet for the two foot take-off".

The Take-Off

Hughes (19) considers the take-off as the most important part of the vault, "...for if the vaulter does not get a strong take-off the rest of the vault suffers". Tenterova (34) notes the spring off the
board when judging the pre-flight phase of the vault. She states that the take-off should be "explosive". Drury and Schmid (9) relate the mechanical aspects as follows: "The take-off should be from the whole foot with a final push off from the toes . . . at the spot of greatest spring on the beat board".

For advanced vaulting, requiring a long and high pre-flight, the body angle at take-off becomes more critical. Hughes (19) and Tieber (35) describe the position when landing on the beat board as leaning backward. The slightly back or vertical position allows the vaulter to stretch upward and forward with the trunk, as the legs push off the board and stretch upward. Tieber also stresses tightening the hip and thigh muscles to achieve full extension of the body.

In a cinemagraphic analysis of the Yamashita vault by Vanis, (37) it was found that a 73 degree backward lean on the take-off board was the most effective of six vaulters filmed. The author concluded also that a take-off time of .04 seconds yielded the best vault. These results might also apply to other vaults, especially those which require passing through the handstand position.

The arm action and eye focus are two other facets of the take-off considered highly important. The arms should be swung backward or downward with the hurdle and forcibly forward and upward at the moment of take-off. (9, 19, 29, 34, 35) Tenterova (33) discussed the effects of arm action accordingly:

"After the take-off the gymnast should fly obliquely with her arms in vertical position because we mustn't forget that the arms play a very important role during the thrust" . . . "When performing the thrust some gymnasts lift their arms bent and close to their body and some lift them straight, using a more swinging action. Using the arms straight is technically more correct because the quick movement of the arms upwards helps the gymnast to make a higher and longer pre-flight."
The eye focus during the running approach should be such that both the board and the horse are seen. It is suggested that at the moment of the hurdle the focus shifts from the board briefly to the horse, and then beyond and slightly upward. (15) The focus at the moment of touch will vary with the type of vault. (9)

In summarizing the importance of the preliminary phases of vaulting, it is noted that many of the problems in vaulting stem from these "unjudged" phases. Frederick (15) makes reference to Lay's (24) evaluation of common vaulting faults:

1. Stiff run. Uneven or short strides; trunk too straight.
2. Take-off spot constantly a mystery.
3. Insufficient thrust from the board; poor coordination of arms and body with the spring of the board.
4. Failure to inhale at take-off.
5. Insufficient layout or stretch of the body.
6. Incorrect push with hands for good off-flight.
7. Trying a vault that is too difficult.

Judged Phases of Vaulting

Pre-flight-Touch

The flight from the take-off board is dependent on two factors primarily: the distance the board is from the horse, and the type of vault being performed. Tieber (35) states that the board is set at a distance according to the student's level, but that there should be enough distance so that the feet have to leave the board before the hands contact the horse: "the distance grows only as the vaulter's skill and confidence grows." As to the type of vault, there are many references
listing them in the progression of their difficulty. (22, 26, 39) In addition, Frederick (15) classifies them according to body action.

The ultimate in vaulting is to achieve a layout, or full extension of the body above the horizontal in the pre-flight. It is described by Tieber (35) as follows:

"The dividing factor between good and mediocre vaulters is the layout. Once students have learned this skill, they not only add difficulty but flare and aesthetic beauty to this event for now they are able to develop further the art of flight. Also, speaking competitively, they are able to execute vaults of the highest point value."

"The layout muscles upon take-off require greater usage of the body as a whole. "... "No one segment plays a leading part, for the vaulter is propelled by overall extension of the body."

The author presents a progression for teaching the layout, involving much practice of the run and take-off to a mat on the floor, with spotters assisting. There is near total agreement that for a layout vault, the run must be increased in distance and speed. (9, 15, 20, 31, 34, 35) With the increased speed of the run, the beat board is placed farther from the horse. The distance must be at least equal to the height of the performer. Drury and Schmid (9) state that, "competitive gymnasts may use the beat board as far as 62-66" from the horse so that they "fly" to the horse and over.

In his progression toward achieving the layout, Frederick (15) suggests teaching tumbling stunts that would aid vaulting skills. These included combinations of a skip, step, handstand, and limber, stressing a "stretch-kick" and handsprings from low heights, with and without take-off board. In another article (16) the importance of achieving a high center of gravity in the handspring with full extension of the body is stressed. This might apply to the vaulting handspring as well.
The desired body angle above the horizontal will vary according to the vault. In layout vaults such as the straddle and squat, the angle is described as 40 to 45 degrees above the horizontal, with the shoulders slightly behind the horse at the moment of touch. (33, 35) The shoulders should never be in front of the hands. (33) In straight arm handsprings, cartwheels, and other vaults in which the body passes through a handstand, the pre-flight angle should be considerably wider, so that the body is almost perpendicular to the horse at the moment of touch. In the giant cartwheel, the vaulter should begin the rotation immediately at take-off. (33)

The touch should be as brief as possible, and should occur at the top of the horse with the arms straight. (33, 34, 35) Regardless of the type of vault, the hands should be aligned, whether they are placed one at a time (cartwheel), or at the same time. (33) If they are not placed on top of the horse, there is an indication of a low pre-flight, and because of the position an inadequate after-flight will follow. (33) Tieber (35) stresses the importance of maintaining the contraction of the muscles during the touch, with particular concentration upon the upper back and shoulder muscles. She notes that students have a tendency to relax this area at the touch, causing an over-arched back, which in turn brings problems in the push-off to after-flight.

Push-Off and After-Flight

In all advanced vaults, the after-flight should be long and high. (13, 28, 30) Frederick (12) credits Yeager (32) with this description: "It is the second stage of a two-stage rocket". For vaults where the performer passes through the handstand, the body remains
extended until landing. (28, 29, 30) In other vaults the hips whip through from an extended to flexed position, with a strong push-off by the hands. It is important that this whipping action does not precede the touch for two reasons. Deductions are made for starting the action too soon, and further, this error generally results in a short or low after-flight, resulting in more deductions. (8, 22, 33)

The landing is to occur in one spot with no extra steps made to maintain balance. (8, 22, 33) This requires knee flexion to absorb the shock and slightly forward bending of the trunk to maintain stability. The arms may reach outward or forward to assist in balance, but should end at the side upon full recovery. (9) Some books state that an extra step may be taken in the line of direction so long as there is no sign of a loss of balance. (8, 22) This rule may be interpreted in several ways and will be discussed further in Chapter V.

Guidelines for Specific Vaults

At a judging clinic given by a representative of the International Federation of Gymnastics, Alenu Tenterova, interpretations were given regarding vault specifications. Some of these descriptions were presented in the lecture (33) and others were given in answer to questions during a personal interview. (34)

Hansprings 90 Degree Turn

In the after-flight the body should remain completely extended with no pike in the hips. There should be no delay in the handstand, but a good push-off and long after-flight. (34)
Handstand Cartwheel (Handstand one-quarter turn wheel out)

This was described as a handstand followed by replacing one hand by the other and wheeling out. It should be done quickly with no pause in the handstand but merely passing through it. This necessitates placing "the arms straight on the horse". (33)

Giant Cartwheel (Cartwheel)

"The gymnasts body should be turned already on the springboard"; good placing of the hands is essential. (33) There is a time when both hands are in contact with the horse, but one must watch where the hands are. They mustn't be too far forward of the shoulders. (34) "When a vault with a turn is carried out, the take-off of the gymnast must be very quick" .... "If the competitor does not pass through handstand she is penalized up to 1.0 point, and if the vault is not continuous the deduction is .5 point."

Handstand Straddle Down, Handstand Bent Leg Squat

The body must be "unbending" in the handstand. A good push-off of the hands plays "a very important role". In the straddle down, care must be taken not to part the legs too soon. (33)

Yamashita

When the Yamashita vault is executed the trunk must be in vertical position and the arms forward. If the arms were stretched sideways the after-flight would be insufficient and the penalty would be .3 point. This vault requires a great height in the first phase and a good push-off. The legs should be drawn to the body in good time. If it is
combined with a turn, the legs must be drawn sooner to allow time for twisting. (33)

**Long Arm Overthrow**

In this vault, the first phase should be as high as possible and the second phase as long as possible. (33)

**Short Vault**

The Czechoslovakian coach stressed continuously the importance of a long and high after-flight. It is considered necessary that the first phase of flight be slightly lower to enable the hips to catch up with the arms in the second phase. In judging demonstration vaults at the clinic, she often stated "it seemed too short", indicating she meant short in height, not in length. Amplitude was the key word of the clinic, a quality "United States gymnasts need". In a report of the vaulting performances at the 1966 World Games in Germany, Tenterova predicted that turning vaults with twists in the pre-flight will soon predominate at major international meets. (33, 34)

**General Rules for Competitive Vaulting**

The most basic rule governing side horse vaulting is that all vaults must be carried out with hands placed on the horse. If a gymnast devises a new vault, she must notify the president of the Technical Commission a month in advance. (22, 33) It might be noted here that in apparent reversal of this rule, Edwards (10) reported "lots of wild mistakes which have been translated into new vaults" at the 1966 World Games.
There are other general rules of vaulting which will be discussed briefly. Each vaulter has two trials for both the compulsory vault and the optional vault. Only the best score of each will be recorded. (8, 22, 33) The vaulter is allowed three running approaches per trial. (33) In example, if a performer in approach to the horse starts her run and veers away, it shall not be considered as a trial if she has not touched the apparatus, (the horse or the take-off board). If she veers away once, however, she must complete the vault on the other two approaches, for they will be counted as trials regardless of whether or not she touched the apparatus. (33) When a vault is established as a compulsory vault it must be performed exactly as it is described. (8, 33) Thus, if the compulsory vault is the layout straddle, the gymnast must achieve a layout in the pre-flight. If she performs a regular straddle vault instead, it will be considered void. In optional vaulting, however, if a vaulter announces one vault, but performs another, she shall be judged on the vault she performed, regardless of what she attempted. Further, a gymnast may elect to perform two different kinds of vaults in her two trials of the optional vaulting.

The compulsory vault is always judged as a 10 point vault, regardless of its established value. (22) Therefore, if the thief vault, a 7.0 vault, were announced as the compulsory, it would be considered a 10.0 point vault, and deductions for performance errors would be made from that level. If a gymnast should elect to perform the same vault as her optional, she would then be judged from 7.0 or the true value of the vault. (34)
Judging Procedures

From the judging viewpoint, vaulting consists of two phases described earlier as the pre-flight-touch and the push-off-after-flight. These viewpoints have been described by Frederick (12) as the "What" and the "How". The "What" is the type of vault performed and its established value as outlined in the rule books. (8, 22, 26, 39) The "How" is the manner in which it is performed. There are a number of items to consider in watching how a vault is performed, but generally they could be categorized under body position and body control in the pre-flight-touch and after-flight. There is a table of penalties established which governs the deductions a judge should make for each error. (8, 22) These tables enumerate up to thirty-three possible errors and suggest deductions ranging from .1 to 3.5 for improper control or position, the amount depending on the degree to which it is varied from the ideal. (8, 22, 33)

The procedure is to note the errors in a vault, total the deductions, and subtract that figure from the established value of the vault. (1, 8, 33) It is stated that there should be five judges to evaluate each performance, and never less than three. (1, 22) One judge acts as the head judge. When there are five or four judges, each arrives at a score, and the highest and lowest scores are eliminated. It is the duty of the head judge to note the point spread among the middle three scores, and if it exceeds the limit designated in the rule book, she must call the judges together for conference and change of scores. It is stated in the rule books (22, 26, 37) that:

"The difference between the highest and the lowest of these three scores taken into consideration cannot be greater than:
.30 for scores between 9 and 10
.50 for scores between 8 and 8.95
1.00 in all other cases."

These restrictions become more refined in the finals of a meet. (22)

It has been observed that this one rule serves to prolong the meet procedures considerably.

The procedure for flashing judges' scores appears to vary with the meet. Tenterova (34) indicated that only the best score is flashed. This was also the procedure at local high school meets in Topeka. At the Nationals and the Pan-American Games, however, the average score of each trial was flashed, so that competitors knew the results of their first trials.

**Qualities of Judging**

In discussion of desirable attributes of a competent judge, Provaznik (30) lists the following:

1. Impartiality.
2. Alertness for detail.
3. Ability to concentrate.
4. Independent and steadfast opinion based on good reasoning.
5. Experience as a gymnast or teacher of gymnastics.

The author suggested also that for the best possible judging, subjectivity should be minimized by: (1) describing compulsories with illustrations, (2) reaching previous agreement on the proper execution, and (3) making preliminary evaluations of difficult moves.

The F.I.G. Code of Points states that there shall be a course for judges preceding all sanctioned meets, lasting two days at the minimum, and that judges who do not take part should not be permitted to serve. (22) This procedure is practiced preceding the Nationals.

Prior to this meet, the judges demonstrate their knowledge of the com-
pulsory routines by stepping through them, and are tested on paper with questions pertaining to the event they are to judge. About vaulting, Bachna (3) suggested these as sample questions: (1) What is the deduction for piking the hips on the straddle before the touch? (2) How should the hands be placed for the giant cartwheel?

It appears that regardless of clinics and judges courses, much is left for the interpretation of individual judges. Davis (6) and Bailie (4) raise questions as to how a judge should rate two techniques or performances of the same point value but of actual difference in difficulty. Further, in his article, Davis prints two letters which discuss the inconsistencies of judging at the Olympics in Japan. There, performers allegedly were awarded scores which the exercise could not possibly merit if executed perfectly, in that they lacked certain difficulty. It was stated that the purpose for these higher scores was to prevent undue embarrassment of countries with the knowledge that only the very highest scores would win. Bailie asks for a new scoring system which would discourage political involvement, and suggests that despite the fact that the Code of Points does not give guidelines for crediting a gymnast for an extra difficult routine, judges award them higher scores. This leads to too much individual variations. Tenterova (34) who represented the F.I.G. at the judges clinic, confirmed this practice with this suggestion: "When a vaulter does something more difficult, such as the Yamashita, or a turning off flight, make less deductions for the same mistakes". She later added, "You must remember what you gave the first (performer)".

It appears that many inconsistencies in judging stem from the translation of techniques from one language to another. Davis (6)
refers to confusion in both the terminology and the illustrations of techniques.

A Different System in Judging

In the contention that many problems in judging arise from judges needing to see too much in too little time, two systems quite similar have been developed. The George V. Bauer variation used in the Big Ten Conference since 1963 (23), divides the responsibility so that each judge is assigned to one particular part of an exercise, and scores upon that part only. Nooney (27) describes a similar system used in the Ontario, Canada schools. Having one judge for execution, one for difficulty, and a combination judge appears especially helpful for inexperienced judges.

The Objectivity of Judging

In a study by Hunsiker and Loken (21), scores of five judges in six events at the 1951 N.C.A.A. Gymnastics Meet were intercorrelated. It was found that most of the correlations were above .85. These authors found also that if all judges' scores were totalled instead of the middle three, the results of the meet would be quite different. In a follow-up study of the same conference, Falkner and Loken (11) intercorrelated scores of four judges. In this study, correlation coefficients were lower, with 26 of 120 below .76 and 15 below .63. The authors concluded that the correlations of judges' scores were exceedingly low, despite efforts to improve objectivity within the ten years following the first study.

Landers (23) compared the Bauer system with the F.I.G. method of judging in a study made in 1965. Twenty-four judges, twelve for
each system, judged twenty-four routines presented on film. In a test of reliability of each system, one routine was presented twice, once in color, a second time in black and white. Three judges using the Bauer system derived the exact same score, giving the Bauer system a higher reliability coefficient of .853. The F.I.G. system, although lower in reliability (.619), had a higher correlation with the absolute score. The absolute score was derived by the author and an experienced judge who made minute study of the film for the difficulties achieved and the form of execution.

In another evaluation of gymnastics judging, Hughes and Kyerson (20) studied the difference in the scores of the high and low judge. In five meets where judges used the one hundred point system the authors found the range of average difference to be between 6.7 and 9.0.
SUMMARY

There is much evidence of current efforts to improve the quality of both the performance and the judging of gymnastics.

Within the past five years, two national institutes on girls sports have provided expert instruction and materials for dissemination to teachers, coaches and students through state clinics. In addition, the establishment and rapid growth of the United States Gymnastics Federation have resulted in growing efforts toward uniformity in compulsory exercises that are graded for all levels of experience. Further, there is evidence of recent research studies which analyze gymnastic performance for the purpose of understanding the various aspects of successful performance.

From the judging standpoint, there are indications of dissatisfaction with the interpretation and translation of international rules and techniques. New systems of judging have been devised in efforts to increase the objectivity in judging, and a research study indicates that one system merits further consideration for adaptation.

For the purpose of interpreting international rules and judging procedures, a representative of the International Federation of Gymnastics was brought to the United States prior to the 1967 National A.A.U. Gymnastics Meet. Through a series of judging clinics, the F.I.G. standards for judging were presented, and aspects of superior performance were demonstrated.
CHAPTER III

PROCEDURE

Design of the Study

This study consists of three distinct parts which will be presented separately. Although the general purpose remained constant with each part, the procedure changed to obtain the data needed. It will be noted that problems experienced in the pilot study precipitated the changes in procedure in the subsequent studies. In each study, however, vault times were recorded for correlation with vault scores.

Pilot Study

Introduction

The purposes of this study were: (1) to determine the degree of correlation between the score of the layout squat vault and the time the vaulter consumed from the moment of take-off to the moment of push-off, (2) to determine the amount of agreement among the judges scoring the vault.

Subjects

The subjects included twenty-four high school girls, performing in the greater Topeka, Kansas area. Data was gathered at six gymnastics meets during the 1967 season.
Equipment and Setting

Two problems became evident with a trial meet, resulting in a change of procedure in the six meets aforementioned. First, it was discovered that there was inadequate differentiation of times when using an ordinary stop watch recording at the nearest 1/10 second. Secondly, the judges flashed their scores only once for each vaulter. Since each vaulter performed two trials, and were scored for only their best, it could not be ascertained for which trial the judges flashed their scores. Thereafter, cooperation of the judges was sought, and forms established for them to record a score for each trial. These forms may be seen in Appendix A.

The Timer: An electric timer which recorded to the nearest 1/100 second was acquired for use in this study. It was controlled by an on-off switch that for optimum consistency was operated by use of both thumbs.

Calculation of Reaction Time: The error of human reaction in starting and stopping the timer was calculated as follows: the face of a stop watch was covered with tape, with the exception of two seconds left visible. The watch was started, and the observer was directed to start the timer when the sweep hand of the stop watch became visible, and to stop the timer when the sweep hand disappeared. A recorder noted the time over or under two seconds to the nearest 1/100 second. Fifty-seven times were summed and then divided by the total. An average error of .009 second was calculated.
Collection of Data

The operator, with timer, extension cord, and forms for recording times, was situated in line with the horse and above it whenever possible. The timer was started when the vaulter contacted the take-off board, and stopped when her hands left the horse. Each trial was timed and recorded by the performer's name. An example of the form used may be seen in Appendix A.

Prior to the meet, each judge was given a form for recording her score for each trial. These were collected at the termination of the vaulting competition of each meet.

Organization of Data

From the six meets, a total of ninety-seven trials of the layout squat vault was scored and timed. These times and scores were plotted on graph paper for correlation in a scatter diagram. In addition, the judges' scores were examined for degree of agreement in the designation of best trials. The average difference between the judge scoring high and the judge scoring low was calculated for compulsory and optional vaults.

As a result of this study, it was decided that timing from the take-off to release of touch was too difficult when it involved human judgment. Consistency in determining when the actual push-off occurred was questioned. It was, therefore, decided that in future studies, the timer would be used for taking the total vault time, and that film would be used for calculating times of specific phases of a vault.
The Nationals Study

Introduction

The purposes of this study were: (1) to determine the correlation of the vault score with: (a) the touch time of the vault and, (b) with the total time of the vault; (2) to learn if body positions during the moment of touch correlated with the vault score; (3) to correlate individual judges scores with the average score; (4) to study trends in judging consistency.

Permission

Two letters were written requesting permission and cooperation in obtaining the times and scores: one to the head judge of vaulting for the 1967 Nationals, and the other to the coach serving as chairman of the women's gymnastics committee of the A.A.U. Permission was received, and assistance given at the meet in the provision of the official score sheet, from which the individual judge's scores were taken.

Subjects

Sixty-eight competitors were timed and filmed while competing in the 1967 Amateur Athletic Union National Gymnastics Meet, held at Northwest Louisiana State College, Natchitoches, Louisiana, May 4-6. The experience of the women vaulters ranged from high school students,

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1Bachna, Janet. 600 Broad Avenue, Canton, Ohio

2Edwards, Vannie. Centenary College, Shreveport, Louisiana
attending their first national meet, to members of the 1964 United States Women's Gymnastics Team.

**Equipment and Setting**

**Timer:** An electric automatic performance analyzer\(^1\) was used to time each vault to the nearest 1/100 second. The timer was so constructed that the controls could be held in one hand, with the thumb free to manipulate the controls. A button was pressed to start the timer, and released to stop it.

**Camera:** A 16mm Bell and Howell movie camera was used for filming the vaults. The type of film used was Tri-X reversal movie film in fifty-foot cartridges. This magazine type camera facilitated the time needed for loading and unloading the film, so that all vaults could be filmed in the sequence desired.

**Collection of Data**

**Judges' Positions:** A sketch was made of the judges' positions in relation to the vaulting action.

**Timing Procedure:** The observer who operated the timer sat approximately six feet above the action, about twenty-five feet from and in line with the take-off board. This position enabled her to see the vaulters' feet in approach to the take-off board and in approach to the landing. The procedure was to start the timer simultaneously with the vaulters' contact with the take-off board, and to stop the timer simul-

\(^1\)Dekan Timing Device, Inc., Glen Ellyn, Illinois
taneously with the vaulter's contact with the mat in completion of the vault. The operator then noted the time and recorded it on the form designed for this purpose. Each vaulter performed two trials of the layout straddle vault, and after each trial the judges deliberated on a score, after which the average score was announced. This procedure allowed time for the operator of the timer to record the necessary information. All optional vaults were timed and recorded also.

Filming Procedure: The camera was mounted on a five-foot tripod, situated approximately eighteen feet from the horse, and about four feet on the after-flight side of a line extending from the horse. The tripod rested on a landing six feet above the level of the floor. It was calculated, therefore, that the camera was approximately eight feet above the top of the horse. The camera was set to record the activity at sixty-four frames per second.

The photographer started the camera at the moment of take off and stopped it after the vaulter demonstrated evidence of balance in the landing. The camera was panned in order to pick up the after-flight and landing. Both trials of the first twenty vaulters were filmed, and thereafter the filming was limited to the first trial of vaulters selected at random. The camera was rewound after each vault and the photographer recorded the names of the vaulters as they were filmed. The balance beam and the balcony rails on the opposite side of the gymnasium served as reference points and standard measures of distance in the common plane.

Judges Scores: The scores of each of the five judges and the average score for each trial were obtained from the meet recorder's
official score sheet. This sheet listed the name of each vaulter and the scores she obtained from each judge.

**Organization of Data**

**Assembling Times with Scores:** The average scores were recorded under the name of the vaulter by trial number. Since each vaulter had two trials, there were two scores and two times for each performer. A table was established by plotting times by their frequency under scores of .4 point intervals. This procedure was followed for the compulsory layout straddle vault and the straight arm handspring vault, a vault selected by fifteen vaulters as their optional vault. All optional vaults were timed, but only the handspring vault was performed by enough vaulters to indicate a trend. With fifteen vaulters selecting the handspring, there were thirty trials to record by score and time.

**Preparation of Film:** The film was processed into four reels of fifty-feet, and observed through the use of a 16mm projector. This was done to identify and verify the order of vaulters by name as recorded by the photographer at the time of filming. Trials that were not clear enough for measurement were eliminated from the list, which was used as a guide for splicing the film into one reel. The film was then observed again to verify the order of vaulters. Most of the vaulters were recognized by name which served as a checking measure against the list compiled by the photographer.

**Measurements taken from Film:** A microfilm projector¹ was used.

¹Dagmar Super Microfilm Reader, Model A, Audio Visual Research, Waseca, Minnesota. Made in Holland
to study the vaulting action one frame at a time. The projection was downward, enabling the observer to use graph paper as a screen upon which angle measurements could be traced. Ten angles of body segments in the plane of flight were measured at specific intervals. This was done by aligning the horizontal lines of the graph paper with two objects known to be parallel with the line of direction of the vaulters. These were the balcony rails on the far side of the gymnasium and the balance beam on the gymnasium floor. The angles measured in the plane of flight, and the phases at which they were measured were as follows:

A. The moment of touch (refer to Figure 1 on page 32.)
   1. The angle of the hips to the horizontal
   2. The angle of the shoulders to the horizontal
   3. The angle of hips in relation to the shoulders
   4. The angle of the feet in relation to the hips

B. Arms perpendicular to the horse (refer to figure 2 on page 33.)
   5. The angle formed by the head to the shoulders
   6. The angle formed by the hips to the shoulders
   7. The angle formed by the feet to the hips

C. At push-off (refer to figure 3 on page 34.)
   8. The angle formed by the shoulders to the hands
   9. The angle formed by the hips to the shoulders
   10. The angle formed by the feet to the hips

The measurements were made with a protractor and recorded to the nearest degree. Forty-eight trials were measured, which included thirty-one different vaulters.

Calculation of Touch Time: The duration of time that the vaulters' hands were in contact with the horse was determined by use of
FIGURE 1

ANGLES MEASURED AT THE MOMENT OF TOUCH
REFERENCED TO THE HORIZONTAL PLANE

1. Hips to the Horizontal
2. Shoulders to the Horizontal
3. Hips to the Shoulders
4. Feet to the Hips
FIGURE 2

ANGLES MEASURED WHEN ARMS PERPENDICULAR REFERENCED TO THE HORIZONTAL PLANE

5. Head to the Shoulders
6. Hips to the Shoulders
7. Feet to the Hips
ANGLES MEASURED AT PUSH-OFF
REFERENCED TO THE HORIZONTAL PLANE

8. Shoulders to the Hands
9. Hips to the Shoulders
10. Feet to the Hips
the microfilm projector. Each frame of the film was counted as $1/64$ second. These times were then calculated to the nearest $1/100$ second accordingly:

$$T = \frac{\text{No. of frames used}}{64}$$

Computation of Data: The forty-eight trials filmed were those vaults used for deriving the intercorrelations of all factors measured. With each trial, eighteen parameters were recorded. These included the total vault time, touch time, five judges' scores, the average score, and the ten angles. The data was organized and placed on computer cards so that it could be processed at the University of Kansas Computer Center. The means, standard deviations, and intercorrelations of the eighteen parameters were obtained by the programing. To determine statistical significance of the results, reference was made to Garrett's Table on correlation coefficients at the .05 and .01 levels of significance. (18)

Judging Profile: Scores of individual judges were plotted on graph paper to illustrate the degree of deviation from the average score. These profiles, which can be seen in Figures 6-10 on pages 45-49 identify judges by letter, an identification established with no particular reference to the original sequence of the judges' numbers.

Top Ten Vaulters Profile: Individual data collected on the vaulters receiving the ten highest scores was considered separately as well as collectively, and can be seen in Table VII, page 67.
The Pan-American Games Study

Introduction

This study was developed to obtain the following: (1) additional total vault times of the layout straddle vault; (2) new phase times, including the pre-flight, touch, and off-flight times of the layout straddle vault; (3) additional total vault times of the straight arm handspring; (4) scores for all the vaults for correlation with the times. In addition, the study was made to observe judging procedures at an international meet.

Subjects

The subjects in this study were competitors at the fifth Pan-American Games at Winnipeg, Canada, July 25-26, 1967. These included twenty-six women gymnasts from five countries: Brazil, Canada, Cuba, Mexico, and the United States. (Each country was represented by six gymnasts with the exception of Brazil, which sent two.)

Equipment and Setting

The Timer: The same automatic performance analyzer was used to time all optional vaults at this meet. The timer was situated approximately ten feet from the take-off board in clear view of both the take-off board and the landing mat. The timer was operated by the same person who timed the vaults at the Nationals.

The Camera: The 16mm. Bell and Howell camera with Tri-X reversal movie film was used in this study. The tri-pod was set directly in line with the horse, thirty feet away and approximately six feet
above the floor level. Since the tri-pod was fifty-four inches high, and the side horse forty-three inches high, it was estimated that the camera was eighty-three inches, or nearly seven feet above the top of the horse.

Collection of Data

Judges' Positions: A sketch was drawn of the seating arrangement of individual judges in relation to the horse.

Timing Procedure: Total vault times were taken for each vault trial, and recorded by the gymnasts name or number. The operator of the timer also recorded the average score for each trial as it was flashed.

Filming Procedure: The camera was used to record all of the compulsory layout straddle vaults. Recording at sixty-four frames per second, the camera was started just prior to the take-off and stopped when the vaulter showed evidence of balance in the landing. The camera was rewound after each vault. The photographer recorded the name, trial, and average score of each vaulter as she was filmed.

Reference Citing: Since it was necessary to pan the camera in order to record all of the vaulting action, a measurable linear distance was filmed for reference later when using the film in calculating velocities. This was accomplished by filming an assistant moving in the same path as the vaulters were filmed, holding a yardstick parallel to that path.
Organization of Data

Optional Vault Times: The total vault times of each vault were assembled with the average score of each vault. Times and scores of the straight arm handsprings of this meet were combined with the data gathered on the same vault at the Nationals, to be computed for means, standard deviations, and correlation of time with score.

Use of Film for Phase Times: Three phases of the layout straddle vault were timed by projecting the film through the microfilm reader. Each frame was counted as 1/64 second. Times were calculated for: (1) pre-flight; (2) touch; (3) after-flight. These times were combined for (4) take-off to push-off; (5) total vault times. The times were assembled by trial numbers, and were processed by a computer for intercorrelations with their average scores.

Tracings from Film: Various flight phases of the vaulter receiving the highest score and two others achieving lower scores on the layout straddle vault were traced on graph, with the use of the microfilm reader. The common reference point for horizontal alignment was the railing boundary of the gymnasium floor. The reference for linear distance was the yardstick, filmed for this purpose. The horse served as a vertical distance reference. Using the segmental method (5), the center of gravity was calculated for three vaulters at various phases of their flights. The calculations for determining the center of gravity of the first place vaulter may be seen in Appendix B.
CHAPTER IV

RESULTS

Pilot Study

There appeared to be no significant correlation between the layout squat vault and the time duration from take-off to push-off. This may be seen in the scatter diagram in figure 4 on page 40. On the basis of the scatter diagram, it was considered unnecessary to determine possible significant differences by statistical means.

The average difference between the score of the high judge and the score of the low judge was 1.13 on the compulsory vault and .99 on the optionals. The judges averaged 75% agreement when indicating the best trial of individual vaulters on the compulsory vault. There was 88% agreement on the optional vaults.

As stated in Chapter III, the method of timing the vaults was changed as a result of this study.

The Nationals Study

Correlation of Times with Scores

There was no significant correlation between the scores and the total time duration of the layout straddle vault. The coefficients of correlation ranged from .0119 to .0941. There was a correlation coefficient of -.6334 on the touch time with the average score. This coefficient was found to be statistically significant to the .01 level. Times and score coefficients may be seen in Table I on page 41.
FIGURE 4

COMPARISON OF LAYOUT SQUAT VAULT SCORE WITH TIME FROM TAKE-OFF TO PUSH-OFF
### TABLE I

CORRELATION COEFFICIENTS OF LAYOUT STRADDLE VAULT TIMES AND SCORES (NATIONALS)

<table>
<thead>
<tr>
<th></th>
<th>Total Time</th>
<th>Touch Time</th>
<th>Judge #1</th>
<th>Judge #2</th>
<th>Judge #3</th>
<th>Judge #4</th>
<th>Judge #5</th>
<th>Avg. Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Time</td>
<td>0.091</td>
<td>0.111</td>
<td>0.022</td>
<td>0.012</td>
<td>0.094</td>
<td>0.039</td>
<td>0.035</td>
<td></td>
</tr>
<tr>
<td>Touch Time</td>
<td>-0.536</td>
<td>-0.616</td>
<td>-0.614</td>
<td>-0.595</td>
<td>-0.599</td>
<td>-0.633</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judge #1</td>
<td>0.837</td>
<td>0.847</td>
<td>0.812</td>
<td>0.869</td>
<td>0.908</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judge #2</td>
<td>0.929</td>
<td>0.892</td>
<td>0.890</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Judge #3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.908</td>
<td>0.896</td>
<td>0.965</td>
<td></td>
</tr>
<tr>
<td>Judge #4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.871</td>
<td>0.943</td>
<td></td>
</tr>
<tr>
<td>Judge #5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.957</td>
</tr>
<tr>
<td>Average Score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Mean Times and Scores

The mean total vault time of the layout straddle vault was 1.14 second, with a standard deviation of .109 seconds. The mean touch time was .386 second, with a .063 standard deviation. The mean of the average score was 6.692, with a standard deviation of 1.33. Ranges, means, and standard deviations of all parameters in this study have been illustrated in Table III on page 51.

Intercorrelations of Judges Scores

There was a high correlation in individual judges scores with the average score. Coefficients ranged from .908 to .965. Intercorrelations among the judges ranged in coefficients of .812 to .929. All intercorrelations may be observed in Table II on page 43. It will be noted in figure 5 page 44 that three of the five judges produced mean averages lower than the mean average score.

Judges Agreement and Consistency

The average difference between the high judge's score and the low judge's score was 1.27 points on the compulsory vault and 1.15 points on the optional vaults. The judges averaged 75% agreement on which trial was best in the compulsory vault, and 82% agreement on the optionals.

The characteristics of the scoring of individual judges may be studied in figures 6-10 on pages 45-49. It is noted that some judges scored consistently above or consistently below the average score, while others deviated alternately above and below the average.
**TABLE II**
CORRELATION COEFFICIENTS OF BODY ANGLES
WITH LAYOUT STRADDLE VAULT
TIMES AND SCORES
(NATIONALS)

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Touch</th>
<th>Judge #1</th>
<th>Judge #2</th>
<th>Judge #3</th>
<th>Judge #4</th>
<th>Judge #5</th>
<th>Avg. Score</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At Touch</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hips to Horse</td>
<td>.130</td>
<td>-.067</td>
<td>.312</td>
<td>.043</td>
<td>.133</td>
<td>.066</td>
<td>.177</td>
<td>.143</td>
</tr>
<tr>
<td>Shoulders to Horse</td>
<td>-.274</td>
<td>-.026</td>
<td>.032</td>
<td>-.193</td>
<td>-.087</td>
<td>-.144</td>
<td>-.079</td>
<td>-.119</td>
</tr>
<tr>
<td>Hips to Shoulders</td>
<td>-.505</td>
<td>-.021</td>
<td>.038</td>
<td>-.221</td>
<td>-.188</td>
<td>-.155</td>
<td>-.102</td>
<td>-.144</td>
</tr>
<tr>
<td>Feet to Hips</td>
<td>.006</td>
<td>.441</td>
<td>.004</td>
<td>-.152</td>
<td>-.088</td>
<td>-.136</td>
<td>-.151</td>
<td>-.130</td>
</tr>
<tr>
<td><strong>Arms Perpendicular</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Head</td>
<td>.004</td>
<td>-.044</td>
<td>.110</td>
<td>.194</td>
<td>.226</td>
<td>.158</td>
<td>.219</td>
<td>.204</td>
</tr>
<tr>
<td>Hips to Shoulders</td>
<td>.222</td>
<td>-.053</td>
<td>.206</td>
<td>.114</td>
<td>.059</td>
<td>.079</td>
<td>.054</td>
<td>.113</td>
</tr>
<tr>
<td>Feet to Hips</td>
<td>-.074</td>
<td>-.099</td>
<td>.154</td>
<td>.032</td>
<td>.165</td>
<td>.122</td>
<td>.162</td>
<td>.134</td>
</tr>
<tr>
<td><strong>At Push-off</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulders to Horse</td>
<td>.118</td>
<td>.317</td>
<td>.077</td>
<td>-.069</td>
<td>-.010</td>
<td>-.064</td>
<td>.006</td>
<td>-.032</td>
</tr>
<tr>
<td>Hips to Shoulders</td>
<td>.311</td>
<td>.184</td>
<td>.099</td>
<td>-.078</td>
<td>-.086</td>
<td>-.057</td>
<td>.055</td>
<td>-.022</td>
</tr>
<tr>
<td>Feet to Hips</td>
<td>-.085</td>
<td>-.206</td>
<td>.042</td>
<td>.033</td>
<td>.150</td>
<td>.053</td>
<td>.105</td>
<td>.091</td>
</tr>
</tbody>
</table>
FIGURE 5

INDIVIDUAL JUDGES’ SCORES IN RELATION TO THE AVERAGE SCORE
FIGURE 6

SCORING OF JUDGE A

--- = First Trial
----- = Second Trial
FIGURE 7

SCORING OF JUDGE B
SCORING OF JUDGE C

FIGURE 8

First Trial

Second Trial
FIGURE 9

SCORING OF JUDGE D

--- = First Trial
----- = Second Trial
FIGURE 10

SCORING OF JUDGE E
Correlation of Body Segment Angles

In Table II it will be observed that there was no significant coefficient of correlation between the scores of the layout straddle vault and any one angle measured in the touch phase. The coefficients ranged from .006 to -.221.

In the correlation of body angles with vault times, the highest coefficient was -.5055, between the total vault time and the angle formed by the hips to the shoulders at the moment of touch.

Intercorrelations among the body angles ranged from coefficients of -.005 to .597. These may be studied in Table IV on page 53.

The Pan-American Study

Correlation of Phase Times with Scores of the Layout Straddle

The timed phases recorded and their correlations with the average score may be observed in Table V on page 54. The coefficients ranged from .009 to .571. The pre-flight time and the after-flight time correlated with the average score with coefficients of .571 and -.530 respectively. These coefficients were found to be statistically significant at the .01 level.

The mean score of the layout straddle vault at the Pan-American Games was 7.7048.

Correlations of the Handspring Vault Times with Scores

In combining the handspring times and scores of the Pan-Am Games with those of the Nationals, a correlation coefficient of -.282 resulted, with the time and score. The mean time of the handspring was 1.349 seconds, with a standard deviation of .085 second. The mean score
### TABLE III

**RANGE, MEAN, AND STANDARD DEVIATION OF TIMES, SCORES AND BODY ANGLES**

<table>
<thead>
<tr>
<th></th>
<th>Mean Time 1.146</th>
<th>Standard Deviation 0.109</th>
<th>Highest 1.32</th>
<th>Lowest 0.74</th>
<th>Range 0.58</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Time from Take-off to Landing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Length of Touch (time)</td>
<td>0.386</td>
<td>0.063</td>
<td>0.62</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td>3. Judge #1 Score</td>
<td>6.54</td>
<td>1.412</td>
<td>9.10</td>
<td>0.00</td>
<td>9.10</td>
</tr>
<tr>
<td>4. Judge #2 Score</td>
<td>6.59</td>
<td>1.415</td>
<td>9.00</td>
<td>0.00</td>
<td>9.00</td>
</tr>
<tr>
<td>5. Judge #3 Score</td>
<td>6.91</td>
<td>1.417</td>
<td>8.90</td>
<td>0.00</td>
<td>8.90</td>
</tr>
<tr>
<td>6. Judge #4 Score</td>
<td>6.94</td>
<td>1.561</td>
<td>8.90</td>
<td>0.00</td>
<td>8.90</td>
</tr>
<tr>
<td>7. Judge #5 Score</td>
<td>6.69</td>
<td>1.276</td>
<td>8.90</td>
<td>0.00</td>
<td>8.90</td>
</tr>
<tr>
<td>8. Average Score</td>
<td>6.76</td>
<td>1.333</td>
<td>8.867</td>
<td>0.00</td>
<td>8.867</td>
</tr>
<tr>
<td>9. Angle Hips to Horizontal at Moment of Touch</td>
<td>40.21°</td>
<td>5.45°</td>
<td>50.0°</td>
<td>30.0°</td>
<td>20.0°</td>
</tr>
<tr>
<td>10. Shoulders to Horizontal at Touch</td>
<td>57.25°</td>
<td>5.45°</td>
<td>67.0°</td>
<td>47.0°</td>
<td>20.0°</td>
</tr>
<tr>
<td>11. Hips to Shoulders at Touch</td>
<td>26.17°</td>
<td>47.04°</td>
<td>40.0°</td>
<td>5.0°</td>
<td>35.0°</td>
</tr>
<tr>
<td>12. Legs to Hips at Touch</td>
<td>192.5°</td>
<td>169.4°</td>
<td>356.0°</td>
<td>0.0°</td>
<td>356.0°</td>
</tr>
<tr>
<td>13. Head to Shoulders when arms perpendicular to Horse</td>
<td>168.5°</td>
<td>11.17°</td>
<td>191.0°</td>
<td>147.0°</td>
<td>44.0°</td>
</tr>
<tr>
<td>14. Hips to Shoulders when Arms Perpendicular to Horse</td>
<td>35.65°</td>
<td>16.70°</td>
<td>119.0°</td>
<td>9.0°</td>
<td>110.0°</td>
</tr>
<tr>
<td>15. Legs to Hips when Arms Perpendicular to Horse</td>
<td>168.5°</td>
<td>25.23°</td>
<td>230.0°</td>
<td>103.0°</td>
<td>127.0°</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>Standard Deviation</td>
<td>Highest</td>
<td>Lowest</td>
<td>Range</td>
</tr>
<tr>
<td>---</td>
<td>------</td>
<td>--------------------</td>
<td>---------</td>
<td>--------</td>
<td>-------</td>
</tr>
<tr>
<td>16. Angle Shoulders to Hand when releasing Touch</td>
<td>105.5°</td>
<td>6.61°</td>
<td>122°</td>
<td>91°</td>
<td>31°</td>
</tr>
<tr>
<td>17. Angle Hips to Shoulders when releasing Touch</td>
<td>41.92°</td>
<td>9.41°</td>
<td>64°</td>
<td>22°</td>
<td>42°</td>
</tr>
<tr>
<td>18. Angle Legs to Hips when releasing Touch</td>
<td>100.1°</td>
<td>26.13°</td>
<td>180°</td>
<td>50°</td>
<td>130°</td>
</tr>
<tr>
<td>At Touch</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>1. Hips to Horizontal</td>
<td>.596</td>
<td>-.057</td>
<td>.041</td>
<td>.107</td>
<td>.290</td>
</tr>
<tr>
<td>2. Shoulders to Horizontal</td>
<td>.273</td>
<td>.229</td>
<td>-.005</td>
<td>-.079</td>
<td>.122</td>
</tr>
<tr>
<td>3. Hips to Shoulders</td>
<td></td>
<td>.097</td>
<td>-.170</td>
<td>-.155</td>
<td>-.088</td>
</tr>
<tr>
<td>4. Feet to Hips</td>
<td>-.124</td>
<td>-.178</td>
<td>.404</td>
<td>.243</td>
<td>.187</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Arms at Perpendicular</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Head Angle</td>
</tr>
<tr>
<td>6. Hips to Shoulders</td>
</tr>
<tr>
<td>7. Feet to Hips</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>At Release of Touch</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Shoulders to Horizon-tal</td>
</tr>
<tr>
<td>9. Hips to Shoulders</td>
</tr>
<tr>
<td>10. Feet to Hips</td>
</tr>
</tbody>
</table>
### TABLE V

**MEANS, STANDARD DEVIATIONS, AND CORRELATION COEFFICIENTS OF PHASE TIMES WITH SCORES OF LAYOUT STRADDLE VAULT**

**Pan-American Games**

<table>
<thead>
<tr>
<th></th>
<th>Average Score</th>
<th>Pre-Flight Time</th>
<th>Touch Time</th>
<th>After-Flight Time</th>
<th>Total Time</th>
<th>Take-off to Push-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Flight Time</td>
<td>-0.5717</td>
<td>-0.2973</td>
<td>-0.304</td>
<td>0.0091</td>
<td>0.3486</td>
<td></td>
</tr>
<tr>
<td>Touch Time</td>
<td>-0.399</td>
<td>-0.399</td>
<td>-0.2494</td>
<td>0.5665</td>
<td>0.7260</td>
<td></td>
</tr>
<tr>
<td>After-Flight Time</td>
<td>-0.637</td>
<td>0.0675</td>
<td>0.2946</td>
<td>0.2419</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Time</td>
<td>0.4697</td>
<td>0.4697</td>
<td>0.2568</td>
<td>0.6367</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Take-off to Push-off</td>
<td>0.3486</td>
<td>0.3486</td>
<td>0.7260</td>
<td>0.7260</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
of the handspring was 7.487, with a standard deviation of 1.018. The frequency distribution of these times with scores may be observed in Table VI on page 56.

**Kinesiological Aspects of a Successful Layout Straddle Vault**

The study of body positions during critical phases of three layout straddle vaults result in these observations concerning the highest scoring vault (9.0):

**Mid Point of Pre-flight**

1. Center of gravity high, near the 12th thoracic vertebra. Head and chest high.
2. Arms forward at shoulder level.
3. Legs fully extended with ankles the same height as the arms.
4. Head up.
5. Full extension of the body, approximately 5 1/2 feet above the floor.

**At Touch**

1. Center of gravity near anterior crest of ilium.
2. Arms straight, with hands on top of the horse, fingers near the edge of the off-flight side.
3. Body and legs extended, with hips at a 48 degree angle to the horizontal. Legs together.
4. Head up.

**At Push-Off**

1. Center of gravity away from the body, nearly chest high.
2. Legs in full straddle, feet nearly in line with hands.
3. Head up.
### TABLE VI

**FREQUENCY DISTRIBUTION OF VAULT TIMES WITH VAULT SCORES OF STRAIGHT ARM HANDSPRING**

<table>
<thead>
<tr>
<th>Time to 1/100 Sec.</th>
<th>Frequency</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4.0-4.9</td>
</tr>
<tr>
<td>1.23</td>
<td>/X</td>
<td></td>
</tr>
<tr>
<td>1.24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.25</td>
<td>///</td>
<td></td>
</tr>
<tr>
<td>1.26</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.28</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.30</td>
<td>///XX</td>
<td></td>
</tr>
<tr>
<td>1.31</td>
<td>///X</td>
<td></td>
</tr>
<tr>
<td>1.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.33</td>
<td>/X</td>
<td></td>
</tr>
<tr>
<td>1.34</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.35</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>1.36</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>1.37</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.38</td>
<td>///XXX</td>
<td></td>
</tr>
<tr>
<td>1.39</td>
<td>/X</td>
<td></td>
</tr>
<tr>
<td>1.40</td>
<td>/X</td>
<td></td>
</tr>
<tr>
<td>1.41</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.42</td>
<td>/X</td>
<td></td>
</tr>
<tr>
<td>1.43</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.44</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.45</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.47</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.48</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>1.49</td>
<td>/</td>
<td></td>
</tr>
<tr>
<td>1.50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.52</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.53</td>
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</tr>
<tr>
<td>1.54</td>
<td>/</td>
<td></td>
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<td>1.55</td>
<td>/</td>
<td></td>
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<tr>
<td>1.56</td>
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<td></td>
</tr>
<tr>
<td>1.57</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.58</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Average Times</strong></td>
<td>1.45</td>
<td>1.42</td>
</tr>
</tbody>
</table>

/ = Nationals Vaulters  
X = Pan-American Vaulters
Midway in Off-flight

1. Center of gravity within the body at mid-hip level.
2. Body fully extended, nearly 90 degree angle to the floor.
3. Head slightly forward.
4. Arms in line with body at sides.

Landing

1. Center of gravity near the ilial crest.
2. Body erect with a slight backward lean.
3. Feet together, in near alignment.

These observations, shown in figure 11 page 58 may be compared with two other vaulters shown in figures 12-14, pages 59-61. It will be noted that in the landing of these two other vaulters, the center of gravity was outside of the body, resulting in a loss of balance.

The film study of vaulting action resulted in two other observations: (1) vaulters who landed on the take-off board with one foot slightly in front of the other, also had one hand slightly in front of the other at the touch, and landed with one foot slightly in front of the other, sometimes off-balance; (2) the jolt to the body at the moment of touch was obvious in all vaulters, and the ability to withstand this jolt by maintaining body extension at this moment seemed to determine the degree of body control in the off-flight.
FIGURE 11

CENTER OF GRAVITY THROUGH FLIGHT OF
WINNING LAYOUT STRADDLE VAULT
SCORING 9.00
(PAN-AMS)
FIGURE 12

CENTER OF GRAVITY THROUGH FLIGHT OF VAULTER
SCORING 7.85
FIGURE 13

CENTER OF GRAVITY THROUGH FLIGHT OF VAULTER WHO FELL ON LANDING SCORING 5.90
FIGURE 14

CENTER OF GRAVITY COMPARISON OF
THE THREE VAULTERS
CHAPTER V

DISCUSSION

Correlation of Times with Scores

Total Time with Score

The key concern of this study was to determine if the time duration of the total vault, or phases of it were related to its score, with the overall purpose being to find an objective base for evaluating vaulting performance. It had been conceived that if there were a high correlation, a scale of times might be established from which to start a score. For example, if the time of 1.28 seconds were considered the best time for the handspring, it could be established as the mark from which form points could be added or deducted. This was on the further assumption that body position during various phases of the vault (i.e. the height of pre-flight and after-flight) would be indicated by the time of the vault, leaving only form breaks for visual judgment.

The results of this study bring much doubt on the possible usefulness of such a method. Since there was no correlation between the total time and the score of the layout straddle vault and an insignificant coefficient of correlation in the handspring vault, use of the total time seems out of the question. Although the trend in the times at the Nationals indicated that the faster the handspring the better the score, when the data was combined with the Pan-Am scores for computation, the trend weakened. It appears that although a faster
running approach is desirable, there is a greater degree of freedom in the speed, distance of the run, and distance between the take-off board and horse to make timing impractical. In addition, some vaulters appeared to "float" through their flights, adding to the vault time, but meriting the same score as the faster, more dynamic flights. In retrospect, it was observed at the high school meets that the gymnasts who first achieved the higher flights were those who had achieved the increase in speed and distance in the running approach. This seemed especially true with the straight arm handspring, and although total times were recorded for these vaults in the pilot study, there was not adequate sample for calculation of correlation of total time with score. With the trend toward more uniformity in coaching for increased speed in the run (7, 13, 16, 26, 29, 30), further study comparing these factors may be warranted, at the high school level.

The fact that there was a low correlation between the body angles and the score may begin to explain the lack of correlation of the total time and score of the layout straddle. Since there was no ideal angle at any one point, it would indicate that a multitude of adjustments are made at various points of the touch, which either enhance or lower the score, but which record the same time. This will be discussed further in relation to the intercorrelations of body angles.

Phase Times with Score

It is interesting to note the differences in correlation of the touch time with the score at the Nationals and the Pan-American Games. At the first meet, the coefficient was -.633, but at the second
meet it was -.249. This might be explained in part by the assumption that there was a greater range in abilities at the Nationals than at the Pan-Am Games. The mean average score at the Pan-Am Games was nearly one point higher than the mean average score at the Nationals.

Although it is stated that vaults should have a long high pre-flight and a long high after-flight (7, 13, 28, 20), the correlation of these two phases with the score indicate that only the pre-flight received merit for its length, with respective coefficients of .571 and -.530. This inverse relationship of the off-flight and the score may be explained in part by the fact that those vaulters who attempted to obtain a longer after-flight may have landed in bad form. This was the case with two of the vaulters selected for the center of gravity study. Although they achieved a longer and higher after-flight than the vaulter who placed first, they both required extra steps for balance in landing, with one falling to her hands. The vaulter who received the highest score achieved a relatively shorter off-flight but displayed remarkable control and form from the push-off to landing. Since her score was 9.00, it can be assumed that she was penalized for the short after-flight but her score was still considerably higher than the 7.85 and 5.90 scores received by the other two. Although these two had other form breaks, including a premature start of the straddle action, it would be safe to conclude that control and form have more bearing on the score than height and length of the off-flight.

Intercorrelations of Phase Times

Although there was not a high correlation of the pre-flight time with the off-flight time, it is interesting to note the inverse
relationship. This trend supports the opinion that with the layout straddle vault, a pre-flight that is too high will result in a short off-flight.

**Intercorrelation of Body Angles**

Although the intercorrelation of body angles produced relatively low coefficients, those that were found to be statistically significant will be discussed briefly.

There is a slight indication that the hip angle at touch will govern the position of the hips throughout the touch to the push-off by its correlation with these subsequent body angles:

1. Shoulders to the horizontal at touch.
2. Hips to shoulders when arms are perpendicular.
3. Shoulders to horizontal at push-off.
4. Hips to shoulders at push-off.

In following the position of the feet in relation to the hips at each phase of the touch, it will be noted that although the coefficients are relatively higher, they are still surprisingly low. It had been assumed prior to this study that the position of feet at the moment of touch would correlate with their position during the straddle action. Apparently the individual differences in initiating the straddle action lowered this correlation. The observations expressed in Chapter IV, regarding the jolt to the body at the moment of touch may explain this and other low correlations of body angles. This jolt had an obvious effect on the control, and may have been a factor in the position of segments throughout the rest of the vault.
Correlation of Body Angles with Times

The assumption that the time of the vault would indicate the body position within the vault received little support from this study. Although the position of the hips in relation to the shoulders correlated with the total time with a coefficient of -.505, no other angles approached a significant relationship with either the touch or total time. This might be explained by two observations: (1) the range in the critical angles of the hips at the moment of touch was relatively small, indicating that most vaulters achieved the desired angle for a layout position; (2) the vaulters varied considerably in body adjustments when whipping the hips through on the straddle, thereby effecting the score, but not the time.

Scoring Trends

Many people feel that judges tend to score higher as the meet progresses. This belief was descredited at the Nationals as will be noted in Table VII on page 67. The vaulter who placed first was the first vaulter. At the Pan-Am games where coaches had the opportunity to place their gymnasts in certain strategic order, the scores indicated that it was not always the strongest performer last. Also, there was little indication that vaulters will do better on the second trial. This will be observed in Figure 15 on page 68.

When asked about the proper position of the judges, Tenterova (29) stated that they should be situated where they can see all phases of the vault, preferably standing. It was observed that the position of the judges varied with the Nationals and the Pan-Am Games. The only judge observed standing in the eight meets attended this year was the
TABLE VII
A SUMMARY OF SCORES TOTAL VAULT TIMES, AND PERFORMANCE
ORDER OF THE TOP TEN VAULTERS AT THE NATIONALS

<table>
<thead>
<tr>
<th>Place</th>
<th>Order of Performance</th>
<th>Total Vault Time in Seconds</th>
<th>Best Trial Avg. Score</th>
<th>Point Difference From 1st Place</th>
<th>Deviation of Judges' Scores From the Average Score</th>
<th>Point Differences Between High and Low Judge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st</td>
<td>1st</td>
<td>1.20</td>
<td>8.867</td>
<td>------</td>
<td>+.3 +.1 +.1 0 -.3</td>
<td>.6</td>
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FIGURE 15

- = Nationals
- = Pilot Study
head judge at the Nationals, who was scoring but not for record. Three judges at the Pan-American Games were seated in such a position that they could see only one phase well, with their chairs either facing the off-flight side of the horse or the far end of the landing mat. (See Figure 16, page 70). Further, their eye level was barely above the floor, as they were seated in a recessed area. This arrangement was altered for the optional vaults, but the original position for judging fifty-two compulsory trials is questioned.

Although the scores of individual judges were not obtained from the Pan-Am Games, there was one problem evident to those present. There was much disagreement of individual judges in scoring the vaults. Although vaulting action takes less time than any other routine in gymnastics, each time the competing groups were ready to rotate to another area, it was the vaulting which delayed the rotation. There were many delays for judges' conferences to adjust the scores in order to meet the rules governing point differences. This was true to some extent at the Nationals as well. There is obviously much disagreement in the evaluation of vaulting. Although part of the disagreement can be attributed to differences in background and methods of practice, it appears that much of it stems from the wide variances allowed for interpreting the present standards.

Judging Objectivity

The correlation of the judges' scores were quite high, with the lowest coefficient being .812. Further, all of the coefficients with the average score were .90 or better. This compares favorably with the studies reviewed on the judging of men's gymnastics. It should be re-
FIGURE 16

POSITION OF JUDGES DURING COMPULSORY VAULTS
AT THE NATIONALS AND PAN-AMERICAN GAMES
membered, however, that the three middle scores on each trial must fall within .3, .5, or .1 depending on the score level which assures very high correlation among these scores. Also, as the meet progresses, and score adjustments are made to meet this requirement, it likewise raises the correlation among individual judges scores.

The degree of deviation from the average, as illustrated in figures 6-10, indicate that adjustments are made by judges on the second trial, suggesting that efforts are made to come closer to the norm established on the first trial. This is especially suspected of Judge A, who often went from well above the average on the first trial to well below on the second. Judge C and B displayed remarkable consistency with C remaining generally above the average, and B staying generally below. Judge E, although deviating from above to below, remained closest to the average. In recalling Tenterova's (29) statement that "One should remember what she gave the first", it seems pertinent to note the consistency of a judge by the degree to which she varies her score above and below the average, especially on the first and second trials of a vaulter.

As stated in Chapter IV, the average difference between the score of the high judge and low judge was 1.27 points. It is significant to note on Table VII page 67 that the point difference between the first place and the tenth place vaulters was 1.30. One might conclude that the average difference of opinion of 2/5 of the judges is nearly equal to the first ten places! It should be remembered too that the 1.27 point difference between high and low judge represents all judges, for at one time or another each was either high or low.
It is surprising that there was less difference in the high and low judges on the optional vaults. This was true in both the pilot study and the Nationals study. It might be concluded that either the layout squat and straddle vaults are difficult to judge, or that after judging so many trials of one kind of vault, one loses the judging trend established and with it, consistency. This possibly accounts for the lower difference between the high and low judge at the high school meets. At these meets, the most vaulters ever judged in one sitting was fourteen. At the Nationals, there were sixty-eight. This makes a difference of over one hundred trials. In addition, the judges at the high school meets were of the same relative experience, and judged together many times, evaluating the same vaulters at different meets.

It is a credit to teachers, however, that although their specialty may not be gymnastics their consistency and agreement in judging compares favorably with the judging of specialists. This is not to say that they were more accurate.

From the observations made in this study, it appears that inconsistencies and differences in opinion of judges is caused less by lack of experience and knowledge of the event and more by the lack of agreement on the interpretation of the standards for judging. Recommendations for future studies in testing other objective measures will be discussed in Chapter VI.
CHAPTER VI

SUMMARY CONCLUSIONS AND RECOMMENDATIONS

Summary

The purpose of this study was to examine certain aspects of judging women's side horse vaulting competition. More specifically, the objectives were: (1) to study the relationship of the time duration of various phases of the vault with the vault score to determine if time could be used as a factor in judging; (2) to examine the consistency of judges in scoring vaulters under the present standards; (3) to study kinesiological aspects of successful vaulting action.

Data were gathered in 1967 at high school meets in Topeka, Kansas; the National A.A.U. Gymnastics Meet, Natchitoches, Louisiana; and the Pan-American Games, Winnipeg, Canada. In addition, a three-day judging clinic conducted by an International Representative of the International Federation for Gymnastics was attended for current information about judging methods and procedures. Data from this clinic were used as reference material and used in the review of literature.

At six high school meets, ninety-seven trials of the layout squat performed by twenty-four gymnasts were timed from the moment of take-off to the push-off with an electric timer. These times were compared with the average score of the judges.

At the Nationals, two phases of the layout straddle vault were timed for comparison with the scores of individual judges and the average of the middle scores. One hundred thirty-six trials were timed
from the point of take-off to the point of landing with an automatic performance analyzer. The optional vaults were timed also. Forty-eight trials of the layout straddle vault were filmed with a 16mm camera at 1/64 second. The film was projected through a microfilm projector to calculate the touch times of the vault and to measure ten body angles of each vaulter during three points of the touch.

At the Pan-American Games, fifty-two trials of the layout straddle vault were filmed with a 16mm camera at 1/64 second. The average score for each trial was recorded. The film was used to measure the time duration of four phases of the vault and the total time. The data gathered at the two major meets were computed separately at the University of Kansas Computer Center.

From the Nationals study, eighteen parameters were computed for intercorrelation coefficients, means, and standard deviations. These eighteen parameters included: vault total time; touch time; five individual judges' scores; the average score; and ten body angles measured at the touch phase.

Data computed from the Pan-American Games included: the average score of each trial; pre-flight time; touch time; pre-flight to push-off time; after-flight time; and total time. In addition, the times of the handspring vaults of both meets were combined for computation of total time with the average scores.

Judges scores were plotted to study characteristics of deviation from the average score of individual judges at the Nationals. The average differences in score between the judges scoring high and those scoring low were calculated also from the data gathered at the high school meets and at the Nationals.
The center of gravity at different phases of the flight of three gymnasts performing the layout straddle vault was calculated for analysis by use of the segmental method.

Conclusions

Feasibility of Using the Vault Time As a Factor in Its Evaluation

Within the limitations of this study, it is concluded that the total time duration of the layout straddle vault has no correlation with its score, and that it, therefore, could not be used as a part of the evaluation of the vault. Further, there is doubt in the feasibility of using phase times in the evaluation under the present regulations of vaulting. It is recommended that with controlled running and take-off distances, future studies on the use of timed phases would be warranted.

The Consistency of Judging Under Present Standards

From the study of scoring done by relatively inexperienced judges at high school meets and that of specialists in gymnastics at the Nationals, it is concluded that consistency and agreement in the evaluation of vaulting is not dependent on experience, but rather the agreement on the standards for evaluation and the interpretation of these standards. It is concluded, further, that present judging procedures are conducive to inconsistency. Additional studies are needed in search of more objective measures for judging vaulting.
Kinesiological Aspects of a Successful Layout Straddle Vault

On the basis of film studies of vaulters scoring high and low, it is concluded that form and control in the push-off to landing phase are more important than the height and distance of the off-flight. It is further concluded that the ability to withstand the jolt which the body suffers during the moment of touch is greatly related to the success of the vault. The vaulters who withstood this jolt maintained body extension at the touch, and displayed more control in the off-flight.

The analysis of the most successful vaulter indicates these conclusions: (1) to maintain best form and control the center of gravity is high in the pre-flight and push-off phases; (2) the high center of gravity is achieved by full body extension in the pre-flight, with chest high, head up, and limbs in near alignment; (3) the high center of gravity in the push-off is maintained by keeping the head and chest up and the trunk extended during the straddle action; (4) control in the off-flight is achieved by early recovery of the center of gravity to the body; (5) this recovery is achieved by accompanying the straddle action of the legs with forceful hip flexion, resulting in rapid alignment of all body segments in the off-flight.

Recommendations

From the observations made in this study and others preceding it, it is concluded that changes are needed in the procedure of judging, with well defined interpretations of the standards. This study has revealed that the mean times of two different vaults were less than 1.30 seconds. This fact and the observation that judges displayed difficulty in reaching agreement on scores, causing delays in major National and
International meets, indicate that further study is warranted. It is suggested that interpretation of judging standards could be defined more clearly. For example, it is stated that the pre-flight and after-flight should be high and long in most vaults. The question is, how high is high, and how long is long? Further, the touch should be only momentary, and should occur at the top of the horse. How long is momentary and where is the top of the horse? These requirements might be better defined by the following guidelines in future studies: (1) identify the minimum and maximum heights desired for the pre-flight and after-flight by lines drawn on a back-drop. The judges could observe if the lines were reached or surpassed by observing the vaulter in relation to the arc drawn on the back-drop; (2) establish definite minimum distance for the off-flight and mark it by white tape on the mat. If preferred, have more than one line with definite positive point value; (3) define the top of the horse with tape in a manner that is done in men's long horse vaulting, so that the hand placement can be noted without doubt; (4) establish a judging system similar to the Bauer system by dividing the responsibilities to pre-flight judges, off-flight judges, and touch judges, with one of each judging height and the other form. These measures might begin to add clarity to the requirements already established. Further, if the run and take-off points were regulated to a degree (according to a height range), further study on the correlation of phase times with scores would be warranted.

The necessity of regulating the point spread between the middle scores is questioned. This procedure adds unnecessary threats to the judges by urging them to adjust their scores to meet a level which they
did not see, and encourages the idea that a judge is inaccurate because her score is not close to the score of another judge. It seems inconsistent to assume that a judge is alternately accurate and inaccurate in her opinion, depending on where her score falls in the continuum. One cannot assume that all five judges see everything to be seen within 1.30 seconds, yet this does not overrule the possibility that the highest or lowest score might be the most accurate score of the trial. The practice of continually conferring to adjust scores is not only disrupting to the concentration and confidence of the judges, but also disquieting for the vaulters next in line. It is significant to note that the judges at the high school meets did not conform to this rule and that this might account for both the higher percentage of agreement on trial scores, and the lower difference between the high and low judge. It is, therefore, recommended that the point spread restrictions of the middle scores be eliminated.
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APPENDIXES
APPENDIX A

Sample Record Sheets for Times and Scores
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APPENDIX B

Segmental Method of Locating Center of Gravity

Vaulter A
## LOCATION OF CENTER OF GRAVITY
### SEGMENTAL METHOD

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The remainder is the distance of body's center of gravity from the axis.
LOCATION OF CENTER OF GRAVITY
SEGMENTAL METHOD

Figure A-1

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<td>.7488</td>
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<td>.8112</td>
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<tr>
<td>Right Thigh</td>
<td>.2316</td>
<td>5.0</td>
<td>1.1580</td>
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<tr>
<td>Left Thigh</td>
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<td>5.0</td>
<td>1.1580</td>
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<tr>
<td>Right Leg &amp; Foot</td>
<td>.1412</td>
<td>11.0</td>
<td>1.5532</td>
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<tr>
<td>Left Leg &amp; Foot</td>
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<td>11.0</td>
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<td><strong>.6152</strong></td>
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The remainder is the distance of body's center of gravity from the axis.
FIGURE 17

LOCATION OF CENTER OF GRAVITY – FIRST PHASE

--- = Arbitrary Axis

___ = True Center of Gravity